V. POTENTIAL ENVIRONMENTAL EFFECTS

A. POTENTIAL EFFECTS OF CONSTRUCTION ACTIVITIES FOR EACH ALTERNATIVE

The potential effects of construction are covered in the following sections for activities that relate to the Savannah River site. The potential effects for geologic disposal are covered in DOE/EIS-0046-D.[1] Specific effects will be covered in separate site-specific EISs when and if actual facilities are proposed.

1. Land-Use Effects

The following components of the waste management alternatives would require commitment of land: 1) an immobilization facility at SRP, 2) a surface storage facility at SRP, 3) a bedrock cavern at SRP, 4) a continuing tank farm at SRP, and 5) an offsite geologic repository.

Any of the land requirements at SRP would be at or near existing chemical reprocessing areas, with the exception of a bedrock cavern, which would be within the site but might be several miles from the present processing areas. A processing facility and a surface facility would each require less than 50 acres. After operations cease, most of this land could be returned to unrestricted use. Any use of seepage basins would occur in areas currently used for that purpose, and the ultimate fate of such land would not depend on effects from long-term waste management activities. A continuing tank farm operation would require about 25 acres of additional land for building new tanks at intervals as often as every 50 years. This requirement would cease if a decision were later made to dismantle old tanks and reuse those sites for new tanks, or if a decision were made that containment of the material with high reliability was no longer necessary because the radioactivity in the waste had decayed to innocuous levels.

A bedrock cavern to dispose of liquid waste at SRP would probably require transfer lines from the location of the present tank farms to the location of the surface access to the cavern. A corridor of land about 100 feet wide and up to 8 miles long would be required. The transfer line would be a monitored, double line encased in a concrete culvert and would release no radioactive materials. The line could be dismantled, and the land could be returned to unrestricted use, if such a program were consistent with overall decommissioning policy for the SRP site.

Both a bedrock cavern at SRP and an offsite geologic cavern would require that the subsurface surroundings remain undisturbed by drilling or mining. The size of such an isolation area has not yet been determined and would depend on detailed physical characteristics to be measured for a specific site and future NRC regulations. Preliminary estimates indicate that exclusion of underground activities in an area about 4 miles in diameter centered over the repository would be adequate. Most of the surface area above the underground exclusion area could be used for normal activities. About 50 acres surrounding the access shafts would probably be controlled.

There are no sites of historical or archeological interest within the SRP boundaries that are being considered for location of waste management facilities. Any such sites that might exist where offsite repositories would be located would be identified in the environmental assessments specific to those facilities.

2. Impact on Animal and Plant Communities

Changes in the local ecology are expected during the disruptions accompanying the construction activities, with reversal of most changes and restoration to a new equilibrium after completion of these activities. Such changes would affect about 100 acres out of about 190,000 acres of land that is primarily pine forest for alternatives that involve new facilities at the SRP site. Clearing of wooded land will result in a loss of wildlife habitat. During such clearing and construction, animals will seek shelter in adjacent wooded areas; however, there may be increased mortality among displaced animals. Some foraging species may be benefited by this activity as new shrubs and low brush develop from natural regeneration.

The areas on the site that are not used for permanent facilities will be reclaimed by landscaping and reseeding. Such measures will minimize the long-term impact on terrestrial biota in the area.

The major potential for adverse impacts on aquatic ecosystems is associated with an increase of suspended solids and siltation in local surface waters resulting from runoff of eroded soil.

Turbid water, besides being aesthetically displeasing, will often be avoided by fish, although fingerlings and adults often are quite resistant to high concentrations of suspended solids for short periods. These effects would be mitigated by use of settling ponds and other measures described in Section V.A.3.

The Savannah River Plant (SRP) site has been designated as an Environmental Research Park. Local animal and plant communities are continuously studied by the Savannah River Ecology Laboratory (SREL) of the University of Georgia. Since the land disturbed by the waste management facilities would be less than one-tenth of one percent of the total SRP site acreage, the quality and continuity of the SREL program would be unaffected.

3. Impact on Air and Water Quality

The air pollution potential during construction would be significant only in the immediate vicinity of the construction activity, where disturbed surface soil would be sprayed to reduce dust to an acceptable level. Construction debris and other solid waste would be burned under carefully chosen weather conditions and would comply with the applicable State of South Carolina regulations. Because the distance to the nearest community is about 12 miles, the air quality at that point would remain almost unaffected.

Sanitary sewage would be treated according to applicable National Pollutant Discharge Elimination System (NPDES) permits. For facilities at the SRP site, a new sewage treatment plant would be built and spray irrigation would be used for the discharges, so that there would be no effluent water entering the streams.

Water use during construction would be from wells in the Tuscaloosa aquifer at a rate of a few hundred thousand gallons per day. Total withdrawal of water from the Tuscaloosa formation at SRP at an average rate of over six million gallons per day has had no discernible effect on water levels in the past 22 years. Use of well water or surface water for construction of offsite facilities, if an alternative plan incorporating offsite construction is chosen, would be covered in an environmental assessment for that site. Excavations for foundations of major structures often require extensive dewatering, in which ground water entering the excavation is pumped out to the surface water. Depending on the local ground water recharge, this dewatering may temporarily lower the water table in the vicinity, or it may affect flow gradients in the ground water in other ways and thus affect the quality of ground water. For facilities to be constructed on the SRP site, such effects would occur only in the immediate area and would not influence the offsite ground water because SRP wells would be in the large Tuscaloosa aquifer. Careful attention will be given to the condition of the water to be disposed of during the dewatering process. For example, settling ponds are frequently used for this purpose.

For all the land used in any of the waste management alternatives, erosion of exposed areas with the potential for siltation of adjacent aquatic systems will be minimized by adherence to Federal guides given in Reference 3 which suggest: 1) limiting vegetation removal to a minimum, especially along stream banks; 2) selecting proper sites for excavation-soil stockpiles; 3) limiting the steepness of inclines; 4) minimizing traffic on the construction site, particularly during wet periods; 5) early stabilizing and replanting of exposed soils; and 6) providing runoff channels and settling areas to collect and settle surface water runoff before releases to bodies of natural surface water.

Special precautions, such as building settling basins, would be taken for SRP construction areas that drain to Upper Three Runs Creek so that the quality and continuity of research conducted at the Savannah River Thermal Effects Laboratory, located downstream, would not be affected significantly.

4. Other Potential Impacts

The major construction projects under any of the alternatives would be processing and surface storage facilities at the SRP site, if an alternative including those operations is chosen. A much larger construction effort involving about 50,000 workers was involved in the early 1950s when the existing SRP facilities were built. Also a construction work force of 1000-3000 has been maintained at SRP almost continuously since plant startup. (It is currently about 1500.) A temporary peak construction force of about 5000 people for the waste facilities (less than 10% of the 1950s force) would need to be accommodated by local services representing a population base of about 300,000 (over three times as large as the early 1950s). Because of the small relative size of the construction force, it is anticipated that this accommodation could be made without disruptive social influences on the surrounding communities.

Construction of the major facilities will cause a significant increase in truck traffic around the plant site. Traffic control measures would be implemented, as required, to control truck traffic and ensure safe operations in the vicinity of communities, intersections in rural areas, and school bus pickup points. Construction workers will also increase the traffic in the area. Special efforts would be made to prevent an increased number of accidents during the period of peak construction.

Noise levels during construction of a surface facility will be of the same magnitude as those for any similar construction project, but the large distance from the construction area to the site boundary would reduce the offsite noise to an unnoticeable level. Construction areas would be monitored for compliance with all applicable regulations regarding occupational noise levels, and protective equipment would be used by workers as required.

The alternatives that involve major construction at SRP would require sewage treatment to serve as many as 5000 temporary construction workers. This function would be carried out using new and existing septic tanks and drain fields, sewage lagoons, and existing sewage treatment plants onsite. A new sewage treatment plant would also be built to serve the operating needs of a processing facility.

A positive benefit to the surrounding communities would result from extra revenues that would accompany the construction projects. Such revenues would be in the form of increased sales taxes and income taxes, if applicable, and purchase of materials and services from local vendors.

B. POTENTIAL EFFECTS FROM NORMAL OPERATIONS FOR EACH ALTERNATIVE

1. Occupational Radiation Exposures

The operations necessary to implement any of the alternative waste management plans will result in small amounts of radiation exposure to the operating personnel. The maximum exposures allowed by DOE radiation protection standards are 5 rems to the whole body each year and/or 3 rems each calendar quarter.[4] Extensive efforts are made to reduce worker exposure to amounts that are as low as reasonably achievable (ALARA) under these limits. These efforts include detailed planning of all work which involves radiation exposure potential to reduce exposure time, to provide adequate shielding, and to preclude radionuclide uptake. Such work is carried out under written procedures that are approved by health physics specialists. These procedures specify the time limits for the work and the protective clothing and equipment required. Depending on the radiation and contamination potential, the work may be continuously monitored by health physicists.

Experience with operation of the Savannah River Plant indicates that actual personnel exposures can be expected to be considerably less than the DOE standards as a result of the ALARA policy. A summary of SRP occupational doses for the period 1965 through 1975 is shown in Table V-1. The annual average dose per monitored employee ranged from 0.22 to 0.59 rem for the period. The maximum individual dose ranged from 2.7 to 3.7 rem, with the exception of a single apparent dose of 24.8 rem to an employee in 1971. This dose was not substantiated in followup investigations.

Work done in the irradiated fuel reprocessing areas at SRP is similar in many important aspects to work that would be done in conjunction with alternatives involving waste solidification. Table V-1A gives exposure experience for workers involved in the SRP reprocessing activities, excluding those whose jobs involve no potential occupational exposure. There is little difference in the exposure received by the average plant employee monitored and those involved specifically with processing operations. The radiation exposures of workers in new waste management facilities would be expected to be even lower than workers in present SRP processing buildings because of greater shielding and improved equipment for handling radioactive material which could be installed in new facilities.

Tables V-2 and V-3 give results of estimating the occupational exposures for each alternative by two different techniques: for Table V-2, individual doses were assumed to be the same as that for the average SRP experience for 1965-1975; and for Table V-3, individual doses were assumed to be equal to the DOE standards

TABLE V-1

SRP Whole Body Occupational Exposure Experience

Year	*Number of Employees Monitored*	*Total Exposure, rem*	*Average Exposure per Monitored Employee, rem*	*Maximum Individual Exposure, rem*
1965	4977	2340	0.47	2.9
1966	5032	2074	0.41	3.4
1967	5041	2604	0.52	3.0
1968	4875	2412	0.49	3.3
1969	4705	2758	0.59	3.2
1970	4626	2353	0.51	3.7
1971	4836	2401	0.50	3.3 (24.8)[a]
1972	5210	1711	0.33	3.4
1973	5005	1488	0.30	2.7
1974	5138	1367	0.27	3.1
1975	5263	1161	0.22	2.7
		Average over Period	0.42	

a. Higher value indicated by initial monitoring but not substantiated by subsequent investigation.

TABLE V-1A

SRP Reprocessing Area Whole Body Occupational Exposure Experience

Year	*Number of Employees Monitored*	*Total Exposure, rem*	*Average Exposure per Monitored Employee, rem*	*Maximum Individual Exposure, rem*
1965	1501	916	0.61	2.8
1966	1497	928	0.62	3.1
1967	1489	980	0.66	3.0
1968	1454	829	0.57	2.9
1969	1441	994	0.69	2.9
1970	1378	868	0.63	2.6
1971	1567	815	0.52	2.8
1972	1756	685	0.39	2.9
1973	1613	742	0.46	2.7
1974	1674	720	0.43	2.9
1975	1781	570	0.32	2.7
	Average over period		0.54	

TABLE V-2

Occupational Radiation Exposures Based on SRP Experience

Alternative	*Operational Modules, rem/year in maximum year*				*Total per Maximum Year, rem*	*Total for Campaign, rem*[a]
	Removal from Tanks	*Processing*	*Transportation*	*Storage*		
Alternative 1 - Continue storage in tanks	5.0[b]	Not applicable	Not applicable	7.6	1.26×10^1	3.56×10^2
Alternative 2, Subcase 1 - Process to glass; ship to offsite geologic disposal[c]	4.2	2.31×10^2	1.40×10^2	0	3.75×10^2	3.75×10^3
Alternative 2, Subcase 2 - Process to glass; surface storage at SRP[c]	4.2	2.31×10^2	Not applicable	6.7	2.42×10^2	2.64×10^3
Alternative 2, Subcase 3 - Process to glass; disposal in SRP bedrock cavern[c]	4.2	2.31×10^2	Not applicable	0	2.35×10^2	2.35×10^3
Alternative 3 - Slurry liquid waste into SRP bedrock cavern	4.2	Not applicable	Not applicable	0	4.2	4.2×10^1

a. See Tavle V-4 and text for campaign times.

b. This exposure occurs only when waste is reconstituted and transferred from an old tank to a new tank and during tank decontamination.

c. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

TABLE V-3

Occupational Radiation Exposures Based on DOE Standards

Alternative	*Operational Modules, rem/year* *Removal from Tanks*	*Processing*	*Transportation*	*Storage*	*Total per Year, rem*	*Total for Campaign, rem*[a]
Alternative 1 - Continue storage in tanks	5.95×10^{1} [b]	Not applicable	Not applicable	9.04×10^{1}	1.50×10^{2}	4.24×10^{3}
Alternative 2, Subcase 1 - Process to glass; ship to offsite geologic disposal[c]	5.00×10^{1}	2.75×10^{3}	1.40×10^{2}	0	2.94×10^{3}	2.94×10^{4}
Alternative 2, Subcase 2 - Process to glass; surface storage at SRP[c]	5.00×10^{1}	2.75×10^{3}	Not applicable	7.97×10^{1}	2.88×10^{3}	3.14×10^{4}
Alternative 2, Subcase 3 - Process to glass; disposal in SRP bedrock cavern[c]	5.00×10^{1}	2.75×10^{3}	Not applicable	0	2.80×10^{3}	2.80×10^{4}
Alternative 3 - Slurry liquid waste into SRP bedrock cavern	5.00×10^{1}	Not applicable	Not applicable	0	5.00×10^{1}	5.00×10^{2}

a. See Table V-4 and text for campaign times.

b. This exposure occurs only when waste is reconstituted and transferred from an old tank to a new tank and during tank decontamination.

c. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

discussed above. The latter is a very conservative assumption because, even if the potential for such exposures existed, it would be impractical and undesirable to rotate and schedule all employees so that everyone received exposure up to the DOE limit. Other assumptions used to prepare Tables V-2 and V-3 are:

- The manpower requirements and time involved for each operation were estimated as shown in Table V-4. Most of the manpower estimates are based on experience with similar operations at SRP. It was assumed that surveillance and monitoring of a continued tank farm or an air-cooled surface vault would be done 24 hours per day. In contrast, a cavern disposal site would have less intense surveillance and would be monitored 24 hours per day by only one full-time person.

- Exposures to drivers and service personnel during offsite transportation are the same as those used in Reference 4 for 3000-mile truck shipments. Exposures reflect the limits specified in Nuclear Regulatory Commission regulations No. 10 CFR 71 (Reference 5) and No. 49 CFR 170-9 (Reference 6).

- For the alternative of continued tank farm operation, it was assumed that each tank would be replaced every 50 years. Radiation exposure would not be received from construction of a new tank, but would be received from the transfer operation between the old and the new tank and from decontamination of the old tank. Each of these operations is estimated to require six employees (including supervision) for six months. Assumed individual exposures were reduced each year to reflect the 30-year half-life of ^{90}Sr and ^{137}Cs, as discussed below.

- A time period of 300 years was used to estimate total exposures received from surveillance and monitoring. Assumed individual exposures were reduced each year to reflect the 30-year half-life of ^{90}Sr and ^{137}Cs, the primary contributors to penetrating radiation that would result in exposure from surveillance and monitoring. After a period of 300 years, individual exposures from these operations would be negligible fractions of natural background and are thus unimportant in the consideration of environmental impact.

- Surveillance and monitoring of a sealed geologic repository, either offsite or in SRP bedrock, would probably be done with a small observation force plus one person collecting and analyzing samples of water from several monitoring wells. These operations were all assumed to result in no exposure above background to the persons involved.

TABLE V-4

Manpower and Time Requirements for Operational Modules

Operation	*No. of Employees*[a]	*Time Required*
Tank farm surveillance and monitoring	21	300 years[b]
Reconstitute, transfer from old to new tank	20	6 months[c]
Decontaminate old tank	31	6 months[c]
Remove 60 million gallons from present tanks, transfer to new processing building	10	10 years
Process 60 million gallons to glass, 10-year time[e]	550	10 years
Transport glass offsite[e]	1100[d]	10 years
Air-cooled vault surveillance and monitoring	21	300 years[b]
Offsite salt cavern or SRP bedrock surveillance and monitoring	5	300 years

a. Include direct supervision but not indirect overhead.

b. Occupational exposures would be negligible after this time. See text.

c. These operations were assumed to be required once every 50 years for each tank for 300 years. See text.

d. This case represents truck shipment of the glass form over a distance of 3000 miles from SRP. Other cases are detailed in Reference 4.

e. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

- The manpower requirements and exposures for reconstituting the waste to a slurry and transferring it to a bedrock cavern at SRP would be the same as those for reconstituting the waste and transferring it to a glass processing building.

2. Non-Nuclear Occupational Risks

Each of the alternative plans carries some non-nuclear risk of minor injuries, major injuries, and death during construction of new facilities and during the operating campaign. (For minor injuries, only first aid is required and no days are lost from work; major injuries involve one or more lost workdays.) Experience with many construction activities at SRP and from 26 years of operations has shown that these risks can be low in magnitude and below those experienced in many other industrial activities. There is no reason to expect such risks associated with any alternative plan to be significantly different. Tables V-5 and V-6 give the results of estimating the number of occupational injuries during construction of new facilities and for the operating phases, respectively. The following assumptions were used to generate data for the tables:

- Construction of a new set of 24 tanks is required every 50 years during the 300-year campaign.

- Manpower and time requirements for construction of new facilities are estimated in Table V-7. For most facilities, the requirements were taken from venture guidance estimates for the actual facilities.[7] For construction of a bedrock cavern at SRP and for an offsite cavern in bedded salt, capital costs from the SRP Defense Waste Document[8] were used with estimates of the split between labor and materials to calculate labor requirements.

- Rates of occurrence of minor injuries, major injuries, and deaths are given in Tables V-7 and V-8 for construction and for routine operations, respectively.[9,10]

3. Offsite Radiation Exposures

All facilities in any of the waste management alternatives will be designed and operated such that radioactive releases from normal operations will be within nationally accepted standards for such releases. The current DOE standards for offsite radiation exposures are shown in Table V-9.[4]

TABLE V-5

Non-Nuclear Occupational Injuries During Construction of New Facilities[a]

Alternative	*Construction of Processing Facilities*	*Fabrication of Transportation Casks and Vehicles*	*Construction of Storage Facilities*	*Total for Campaign*
Alternative 1 -				
Continue storage in tanks	Not applicable	Not applicable	1600[b] 17	1600 17
Alternative 2, Subcase 1 -				
Process to glass; ship to offsite geologic disposal[c]	460 5	39 0.5	28 0.4	530 5.9
Alternative 2, Subcase 2 -				
Process to glass; surface storage at SRP[c]	460 5	Not applicable	130 1.4	590 6.4
Alternative 2, Subcase 3 -				
Process to glass; disposal in SRP bedrock cavern[c]	460 5	Not applicable	88 1.1	550 6.1
Alternative 3 -				
Slurry liquid waste into SRP bedrock cavern	Not applicable	Not applicable	180 2.2	180 2.2

a. Two annual numbers are given in each column for each alternative: top numbers are major injuries; bottom numbers are deaths.

b. These include construction of new tanks every 50 years during the 300-year period.

c. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

TABLE V-6

Non-Nuclear Occupational Injuries During the Operating Campaign[a]

Alternative	*Operational Modules* *Removal from Tanks*	*Processing*	*Transportation*	*Storage*	*Total per Year*	*Total for Campaign*[b]
Alternative 1 -						
Continue storage in tanks	5.5[c] 0.0047 0.00059	Not applicable	Not applicable	3.0 0.0027 0.00034	8.6 0.0074 0.00093	1160 1.03 0.13
Alternative 2, Subcase 1 -						
Process to glass; ship to offsite geologic disposal[e]	1.5 0.0013 0.00016	80.5 0.078 0.0089	*d* 1.6 0.052	0.58 0.00051 0.00006	83 1.7 0.061	990 16 0.63
Alternative 2, Subcase 2 -						
Process to glass; surface storage at SRP[e]	1.5 0.0013 0.00016	80.5 0.078 0.0089	Not applicable	2.3 0.0021 0.00026	84 0.081 0.0093	1500 1.3 0.17
Alternative 2, Subcase 3 -						
Process to glass; disposal in SRP bedrock cavern[e]	1.5 0.0013 0.00016	80.5 0.078 0.0089	Not applicable	0.58 0.00051 0.00006	83 0.080 0.0091	990 0.87 0.11
Alternative 3 -						
Slurry liquid waste into SRP bedrock cavern	1.5 0.0013 0.00016	Not applicable	Not applicable	0.58 0.00051 0.00006	2.1 0.0018 0.00022	190 0.16 0.021

a. Three annual numbers are given in each column for each alternative: top numbers are minor injuries; middle numbers are major injuries; bottom numbers are deaths.

b. See Table V-4 and text for campaign times.

c. These include reconstituting waste and transferring to new tanks every 50 years and decontamination of old tanks.

d. Transportation accident data were taken from Reference 8.

e. These numbers were developed specifically for glass waste forms, but should be quite similar for most of the other immobilization forms being investigated.

TABLE V-7

Injury Rates During Construction of New Facilities[9]

	Occurrences per Million Man-Hours	
	Major Injuries	*Deaths*
Mining Caverns	25	0.31
Casks and Vehicles	26	0.32
All Other Construction	16	0.17

Construction Time and Manpower Estimates

Construction Operation	*Man-Hours Required (millions)*	
Processing Facilities	29	
Transportation Casks and Vehicles	1.5	
Set of 24 New Tanks	17	One set every 50 years for 300 years
Air-Cooled Surface Storage Vault	8.1	
Mining Bedrock Cavern (Liquid)	7.2	
Mining Bedrock Cavern (Glass)	3.5	
Mining Offsite Salt Cavern	1.1	

TABLE V-8

Injury Rates During Routine Operations[a]

Occurrences per Million Man-Hours		
Minor Injuries	*Major Injuries*	*Deaths*
50	0.044	0.0055

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a. Based on SRP operating experience over the ten-year period 1967-1976.[9]

TABLE V-9

DOE Radiation Exposure Limits to Offsite Individuals, mrem

Type of Exposure	*Maximum Individual Exposure*[a]	*Exposure to Average Individual*
Whole Body	500	170
Gonads	500	170
Bone Marrow	500	170
G. I. Tract	1500	500
Bone	1500	500
Thyroid	1500	500
Other Organs	1500	500

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a. These individuals are assumed to be at the site boundary under conditions of maximum probable exposure.

The facilities must be operated to fall within the limits discussed above; they will also be operated so that exposures are kept as low as reasonably achievable. In all likelihood, this will result in extremely low, if not zero, exposures from the long-term storage or disposal facilities, with offsite exposures from the handling and processing operations that are comparable to those currently experienced from similar activities at SRP. In 1976, these exposures to a hypothetical individual receiving the maximum dose* were below 1 mrem from all SRP activities. These SRP exposures included contributions from the reactors and from isotopes such as ^{3}H, ^{85}Kr, ^{41}Ar, and $^{133,135}Xe$ that would not be released in significant quantities in the waste handling and processing operations. Routine exposures from SRP are discussed more fully in Reference 11.

Routine releases of radioactivity for an offsite geologic repository in salt have been analyzed by the Battelle Pacific Northwest Laboratories as part of their studies of geologic caverns for commercially generated waste.[1] They consist of only a few hundredths of a curie per year of ^{220}Rn and ^{222}Rn, which would be released as decay products from naturally occurring radium in the salt that must be mined during the years of emplacement. The radiation exposure that could result from this radon release is negligible to offsite individuals.

Emission Control Features of an Offsite Geologic Repository in Salt

All structures are maintained at a negative pressure relative to the atmosphere, and all entries into and from confinement areas are made through air locks. Contamination is controlled by directing air flow from areas of least contamination potential to areas of increasing contamination potential. Air discharged from confinement areas is exhausted through a prefilter and two high-efficiency particulate air (HEPA) filters. Ventilation systems are backed up by standby facilities to maintain confinement in the event of fan breakdown, filter failure, or normal power outage. Automatic monitoring of all potential sources of contaminated effluents is provided with remote readout and alarm at both the central control room in the mine operations building and the guardhouse.

All wastes arriving at the repository are fully contained in stainless steel canisters or steel drums. As a result, the only sources for airborne emissions from these waste containers are handling accidents that could damage and breach the canisters. Potential accidents are described in Section V.C.

* These individuals are assumed to be at the site boundary under conditions of maximum probable exposure.

Liquid wastes generated as a result of decontamination operations are processed onsite. Liquid radioactive waste systems include surge tanks, a waste evaporator, and a liquid waste solidification system. After evaporation and solidification, the wastes are transferred to below ground areas for disposal.

Solid wastes are processed through one of two onsite waste balers where they are sealed into drums. These wastes are then transferred to the mine for disposal.

Sanitary waste (nonradioactive) is collected in a sewer system which is connected to the local sewer trunk, if available, or given secondary treatment onsite and then disposed of in accordance with local and Federal regulations.

4. Nonradioactive Pollutants

No mechanisms have been identified for chemical releases under normal conditions for the storage or disposal modes; therefore, the following discussion is concentrated on processing operations.

If the waste is fixed in glass or other immobilization forms requiring high temperature processing, there will be releases from the processing operations to the atmosphere and to the onsite streams of chemicals such as Hg, NO_X, NH_3, CO_2, NaOH, $NaNO_3$, and heated water. These releases, when combined with those from other activities at SRP, must be within emission standards set by the states of South Carolina and Georgia and the Federal Government.[12,13] Some of the more important of these standards are shown in Table V-10. In addition to the limits imposed by the above standards, SRP operates under National Pollutant Discharge Elimination System (NPDES) permits that limit the discharge of pollutants to tributaries of the Savannah River.[14]

Waste management policy at SRP is to limit releases of potentially polluting chemicals to levels that are lower than those required by the standards and permits, to the extent that is reasonably achievable. This policy is implemented by operating controls and by engineering systems such as liquid-gas absorbers, catalytic converters, "cold-caps," wet scrubbers, absorbers, quench towers, sintered metal filters, iron-oxide mesh filters, venturi scrubbers, cyclone separators, condenser-absorber combinations, and HEPA filters. The extent to which these systems are needed and the releases to the environment that are to be expected

TABLE V-10

Typical State and Federal Air and Water Quality Standards[a,12,13]

Pollutant	*Limiting Concentration*	*Comment*
SO_2	80 $\mu g/m^3$	Ambient air, South Carolina
SO_2	43 $\mu g/m^3$	Ambient air, Georgia
SO_2	1300 $\mu g/m^3$	One-hour, air, South Carolina
SO_2	715 $\mu g/m^3$	One-hour, air, Georgia
SO_2	3.5 $lb/10^6$ Btu	Air emission, South Carolina
Particulates (Fly Ash)	0.6 $lb/10^6$ Btu	Air emission, South Carolina
NO_x	100 $\mu g/m^3$	Ambient air, South Carolina and Georgia
H_2S	10 ppm, 8 hr	Air, detectable effects
Non-Methane Hydrocarbons	130 $\mu g/m^3$	Three-hour, air, South Carolina
Sulfate	250 ppm	Drinking water standard, Federal
Chloride	250 ppm	Drinking water standard, Federal
Nitrate	10 ppm	Drinking water standard, Federal
Barium	1 ppm	Drinking water standard, Federal
Iron	0.3 ppm	Drinking water standard, Federal
Boron	1 ppm	Drinking water standard, Federal
Zinc	5 ppm	Drinking water standard, Federal
Chromium	0.05 ppm	Drinking water standard, Federal
Manganese	0.05 ppm	Drinking water standard, Federal
Arsenic	0.05 ppm	Drinking water standard, Federal
Mercury	0.002 ppm	Drinking water standard, Federal
Copper	1 ppm	Drinking water standard, Federal
Phenol	0.001 ppm	Drinking water standard, Federal

a. The above listing is not meant to imply that all the chemicals would be released from the waste management facilities.

will be determined as the research and development program proceeds and detailed design studies are made. Operation of similar processes and pollution-abatement devices at SRP is described in detail in Reference 11, where it is shown that SRP emissions to the atmosphere have been far below the standards shown in Table V-10, with the exception of particulates from some of the coal-burning power plants. Electrostatic precipitators have been installed on the largest power plants, and prototype improvements are being tested on other plants to ensure conformance with South Carolina emission standards for particulates.

Water that discharges from the SRP creeks to the Savannah River now meets Federal and State of South Carolina regulations. Currently the water discharged to the onsite creeks does not always meet these regulations. However, a project is under way with an expected April 1981 completion that would bring most discharges from individual operating sites into compliance with NPDES Permit No. SC 0000175 before those discharges enter the creeks.[14] Most of the water covered in the project is runoff from coal piles and ash basins, and is of low pH with high suspended solids.

In addition to the emissions to water and air described above, there will be low levels of occupational exposure to nonradioactive pollutants of some workers. Such exposures would occur during processing operations, but not during transportation, storage, or disposal. Reference 14 specifies limits and controls required for exposure to chemicals as legislated by the Occupational Health and Safety Act. Concentrations in air of chemicals to which the worker is exposed will normally be maintained by engineering controls such as ventilation at less than the action level values specified in Subpart Z of Reference 15. Potential exposure of the worker is limited because the chemicals are normally introduced into the process within ventilated enclosures designed to contain radioactivity. Exposures may occur in storage areas, during transport of chemicals from the storage areas, and during preparation of the chemicals for the processes. When concentrations are above an action level, routine monitoring is required rather than audit monitoring. When threshold limit values are exceeded, workers will wear personal protective equipment including respiratory protection as prescribed in Subpart I of Reference 15. Engineering controls would be added or modified to reduce transient high concentrations to less than threshold limit values. Records are required for each worker exposed to chemicals at concentrations greater than threshold limit values.

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* Project 78-SR-023 ($9.2 million).

5. Thermal Discharges

The amount of heat generated in any of the waste management operations is probably less than 10% of that from current SRP heat sources, such as nuclear reactors and coal-burning power plants. The total impact of SRP heat sources is within NPDES and State of South Carolina standards for the Savannah River (Table V-11). The following are sources of thermal discharges that would occur in the three alternative plans:

- Reconstituting the waste to liquid and evaporating it back to damp salt cake and sludge, as in transferring the waste from old tanks to new tanks if tank farm operation is continued.
- Processing reconstituted waste to an immobilization form.
- Storage of canned waste in an air-cooled surface vault.
- Additional power generation.
- Decay heat from disposal of waste in a geologic repository.

With regard to heated water discharges, most states are promulgating thermal standards under the state participatory provisions of the EPA's National Pollutant Discharge Elimination System (NPDES). These standards, which are subject to approval by the EPA, are used in writing NPDES discharge permits. A plant operator must obtain the required NPDES discharge permit from a state agency, or from the EPA if the operation is to be conducted by a Federal agency. The South Carolina standards that pertain to SRP operations and are part of the NPDES are as follows:

- The water temperature shall not exceed 90°F (32.2°C) as a result of heated liquids at any time after adequate mixing of heated and normal waters.

- After the water passes through an adequate zone for mixing, the temperature shall not be more than 5°F (2.8°C) greater than that of water unaffected by the heated discharge.

- The mixing zone shall be limited to not more than 25% of the cross-sectional area and/or volume of the flow of the stream and shall not include more than one-third of the surface area measured shore to shore.

As shown in Table V-11 and discussed more fully in Reference 10, current SRP operations satisfy all three of the water quality standards on temperature in the Savannah River. Present temperature increases in the river are almost completely due to operation of the production reactors, and any future waste management operations would cause an insignificant perturbation compared to this source. The largest potential warm water releases would be from the evaporators used in a continued tank farm operation or in processing the waste, but the condensate from these evaporators will be reused for slurrying other tanks, etc., rather than being released to the river.

As a further consideration regarding warm water releases to the river, the Limnology Department of the Academy of Natural Sciences of Philadelphia has carried on a continuing program of scientific investigation in the Savannah River, beginning with a baseline study in 1951. The baseline study considered all the major groups of aquatic organisms – the protozoa, lower invertebrates, insects, fish, and algae – together with the general and physical characteristics of the river. Since the baseline study, the program has consisted of spot checks four times yearly, detailed studies at 3- to 5-year intervals, and continuous diatometer studies. The 1951 to 1970 summary report of these studies[16] concludes that "there was no evidence in any of the areas studied of the effects of increases in temperature in the river caused by activities of the Savannah River Plant."

With regard to heated air discharges, the canned waste stored in an air-cooled vault would be cooled by natural convection and would generate about 2 megawatts of heat. This is a very small amount of heat dissipation compared to that of other facilities, such as the coal-burning power plants, which have been observed to cause no detectable environmental or noxious effects from heat.

TABLE V-11

Compliance by SRP with S. C. Standards for Temperature in the Savannah River

Criterion	*Standard*	*Maximum SRP Value*
Maximum temperature below SRP after mixing	32.2°C (90°F)	29.4°C[a]
Maximum temperature increase	2.8°C (5°F)	3.7°C[b]
Maximum mixing zone (% of cross-sectional area)	25%	<20%
% of surface area	33-1/3%	<25%

a. Maximum recorded below SRP.

b. Measured during May 1977 (one-time occurrence). Otherwise, the maximum increase has been 1.4°C, calculated using classified information for two reactors discharging to the river at minimum river flow.

C. POTENTIAL EFFECTS FROM ABNORMAL EVENTS FOR EACH ALTERNATIVE

Details of consequences and probabilities for a wide range of abnormal events will be published in Safety Analysis Reports dealing with all aspects of the waste management system that is finally selected. Such analyses must await detailed system designs based on results of the research and development program and the final alternative chosen for implementation. One of the primary purposes of the research and development program is to develop the design of the various parts of each alternative to ensure a high degree of confidence in acceptable safety regarding abnormal events, no matter which alternative is chosen.

Preliminary analyses have been reported in Reference 8 for risks from unusual events that might occur in all operations involved in any of the alternative plans. Events considered were major process incidents, natural events such as tornadoes and earthquakes, sabotage, airplane crash, and abandonment. When lack of detailed system design precluded the usual fault tree/event tree type of analysis, magnitudes of possible events were chosen using the judgment of technical persons familiar with 25 years of operations of similar facilities. The magnitudes were chosen to be upper bounds of credible occurrences. This approach provides a sound physical basis to obtain release fractions, to follow environmental pathways, and to calculate radiation exposures. Many of the probabilities used have a sound basis from either similar operating experience, analysis, or observation of natural events. However, some of the probabilities are only rough estimates, particularly those for sabotage or abandonment. The section on sensitivity analysis discusses the effects on overall risk that would result by varying the uncertain probabilities over wide ranges. Magnitudes of consequences for each event are also available in Reference 8 and can be used in combination with individual decision-maker's probabilities to calculate the resulting risks from these events, if desired. Detailed results from Reference 4 are reviewed in the discussion below. In general, they show that consequences alone, without regard for probabilities, do not pose any disaster potential for the offsite population because individual doses that could occur are comparable to background doses in most cases. When formal analyses are made of systems in a specific alternative, the results will probably show much lower risks than the generic studies.

Pathways from the waste to man that were considered are ingestion of airborne particles, land contamination from fallout of airborne particles, drinking water from the Savannah River, fish consumption from the Savannah River, and possible future use of local sections of the Tuscaloosa aquifer for drinking water. These pathways are discussed in detail in the DWD (Reference 8) and its references at the point that each event involving a specific pathway is covered. The pathways all represent pessimistic assumptions about meteorological conditions and water use, with no warnings or corrective actions. This method of considering pathways, along with the upper limit bounding of possible radioactive releases discussed above, should ensure that upper bounds of consequences from the important events have been covered.

Some of the important physical reasons why the hazards associated with the waste are limited include:

- Very large amounts of energy are required to create waste particles small enough to be widely distributed through the airborne pathway. This is true on a per curie basis for the salt cake and sludge currently stored in tanks as well as for the high-integrity forms like glass.

- There are no internal sources of high energy as part of normal operations in the waste management systems. Energy required to release radioactive particles would have to be introduced externally or in some abnormal manner.

- There are no radioactive noble gases or significant amounts of easily volatilized radioactive elements in the waste that could contribute to potential doses from the airborne pathway.

- High-integrity waste forms and the engineered surface or geologic storage facilities proposed for long-term waste storage can impose major barriers against waste migration.

- Liquid releases from SRP would be absorbed in the soil or diluted many orders of magnitude by the onsite creeks and swamps and by the Savannah River before reaching drinking water users. Even if diversion systems fail and no corrective actions are taken, no large individual doses can occur. None of the alternatives propose handling liquid wastes at any site other than the SRP site.

- The SRP waste facilities are within a large exclusion area.

An added level of accident protection to both workers and offsite population is provided by the design of waste management facilities. The construction methods and materials that meet routine radiation shielding requirements and that ensure adequate resistance to earthquakes and tornadoes also provide resistance and containment for other unlikely incidents.

1. Occupational Radiation Exposures

All the very low probability events that have some potential for releasing radioactive materials offsite also have the potential for exposing working personnel to high radiation levels. These events include major process incidents, tornadoes and earthquakes of incredible magnitude, sabotage, and airplane crashes. The distribution of radiation effects among the personnel at the site is impossible to predict because it would depend on precise details of location of the personnel and corrective actions relative to the chain of events underway. This is in contrast to the predictability of offsite effects (discussed in Sections V.C.3. and V.C.4. below), where the major determinants are amount of activity released and meteorology or water flow patterns. However, the radiation would probably be a small contributor to the worker injuries in these unlikely events; most of the injuries would be from explosive forces, falling buildings, tornado-driven missiles, fire, saboteur gunfire, etc.

Even though consequences mentioned above are possible, their occurrence is extremely unlikely. This fact is generally illustrated by formal safety analyses of existing and designed nuclear systems, and by the experience of the commercial and defense nuclear enterprises over the past thirty years. When this low probability of occurrence is considered, the resulting occupational risk (the product of consequence times probability) from radiation exposure is negligible for any alternative plan.

2. Non-Nuclear Occupational Risks

The non-nuclear risks to onsite workers from abnormal events are in the same category as the risks discussed above for radiation exposures, in the sense that injuries are possible but the likelihood of occurrence is so small that the risks are negligible. The number of injuries possible for each abnormal event is difficult or impossible to estimate because of the mitigating effects of forewarning, corrective action, etc. However, there has been no mechanism identified with the radioactive nature of the waste management alternatives that would increase the non-nuclear risks above those normally experienced in any large industrial operation. In practive, the unusually heavy construction of the waste management facilities would probably provide greater worker protection against abnormal events than that afforded by most other industrial facilities.

3. Offsite Radiation Exposures

Analyses have previously been reported[8] which estimate, using pessimistic values where assumptions are necessary, the offsite radiation exposures that might occur for a variety of abnormal events. The events considered were major process incidents; natural occurrence such as tornadoes, earthquakes, floods, and meteorite impact; sabotage; airplane crash; and abandonment. The analyses were performed for each of the three major alternatives, and within each alternative the analyses considered the four major modules: removal from tanks, processing, transportation, and storage. The results are given as consequences (measured by radiation dose commitment) to offsite individuals receiving the maximum dose and to the offsite population within 150 km. The consequences were then multiplied by an estimate of annual probability of occurrence to obtain annual risk. Finally, the annual risk was integrated over time, accounting for radioactive decay and population growth, to obtain total risk for the period. The detailed integrations are given in the Tables for a period of 300 years, the period of maximum risk before the ^{137}Cs and ^{99}Sr have decayed. (After 300 years of decay, individual doses that could occur from any of the events analyzed are negligible.) Population exposures integration to 10,000 years are also included and show the small additional impact of the long-lived isotopes. These data are given in Tables V-12 through V-16 for Alternatives 1-3. They show that there is no disaster potential to the offsite population from abnormal events for any of the alternatives. Although some of the maximum individual doses are of concern, they could occur to only a limited number of people and are calculated assuming no corrective actions are taken. Doses to average individuals in the nearby population would be thousands to tens of thousands of times lower, depending upon pathways, and therefore would be inconsequential compared to even the variation in natural background in the local area.

Regarding the vulnerability to sabotage or terrorism, there is no firm basis for estimating the probability of sabotage of waste processing or disposal facilities, and the probabilities used to complete the risk analysis are somewhat arbitrary. However, the consequences of credible sabotage events do have a sound physical basis. These consequences were found to be very small compared to levels that would possibly be attractive to terrorists, and indicate that the probability of sabotage being attempted is very low.

The exception to this situation is for liquid waste stored in a bedrock cavern. However, for this case, it is extremely unlikely that people would continue to drink well water from a location directly over a leak into the aquifer. Engineering design and safeguards aimed specifically at the problem of sabotage of the shaft or earthquake while filling would greatly reduce the risks below those pessimistically assumed for the analysis in this EIS. Examples of precautions that have been suggested in comment letters and elsewhere are: reinforced bulkheads sealed against backflow; small-diameter, double-walled piping; shock-proof mounting; and quick-acting shut-off valves at top and bottom. Furthermore, there are corrective actions that would be carried out if the shaft did fail because at the time the shaft would be open there would also be men, equipment, and technology readily available to either clear the shaft or re-seal it[8] (see Section XI).

Risks from storage or disposal in an offsite geologic repository are based on analyses prepared for the *EIS for Management of Commercially Generated Radioactive Waste*,[1] but modified to account for the differences in volume and radioactivity content between SRP waste and commercially generated waste. The base case of disposal in a geologic repository was chosen because more extensive research has been done on this disposal alternative than on others. The analyses in Reference 1 are based on the very conservative assumption of no radionuclide holdup by the geologic medium in the event of unforeseen release of radioactivity to the repository, and therefore the results are independent of whether the repository is located in salt, basalt, granite, or some other medium. Table V-17 gives the events that have been identified for abnormal releases, the estimated release of the major radioisotopes if SRP defense waste were in the repository, and the estimated frequency of occurrence of each event. When probability of occurrence is taken into account, the risk from all these events is negligible compared to the natural background exposure to the same individual. This is shown in Table V-17A, which is compiled from Reference 1 for commercial waste; the impacts from a repository containing defense waste would be even smaller. Other studies on the general subject of radiation risks from a geologic repository may be found in References 17 and 18. Environmental impact statements and safety analysis reports will be published for specific offsite repositories when decisions are made on their locations.

TABLE V-12

Summary of Exposure Risks for Alternative 1 - Storage of Waste as Sludge and Dump Salt Cake in Onsite Waste Tanks (Present SRP Waste Management Technique)

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks	Not applicable	Not applicable	Not applicable	Not applicable
Processing	Not applicable	Not applicable	Not applicable	Not applicable
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Routine Releases	Negligible	1.4	1.0	1.4
Spill during Transfer	2.2×10^{-2}	5.3×10^{2}	5.0×10^{-3}	2.6
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage by Dispersal	3.3	2.3×10^{4}	1.0×10^{-5}	2.3×10^{-1}
Sabotage by Explosion	4.1	9.8×10^{3}	1.0×10^{-5}	9.8×10^{-2}
Airplane Crash	4.1	1.1×10^{4}	1.0×10^{-5}	1.1×10^{-1}
Abandonment	3.9×10^{-1}	2.7×10^{4}	1.0×10^{-5}	2.7×10^{-1}

Time-Integrated Risk, 300 years, man-rem[a]	1.4×10^{3}
Time-Integrated Risk, 10,000 years, man-rem	2.3×10^{3}
Risk with Abandonment after 100 years[b]	2.4×10^{4}

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

b. Population risk integrated for 300 years, if tanks are assumed to be abandoned after 100 years, in accordance with proposed EPA criterion on duration of administrative control.

TABLE V-13

Summary of Exposure Risks for Alternative 2, Subcase 1 – Glass Stored in Offsite Geologic Storage

Event	*Maximum Individual Dose, rem*[a]	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing				
Routine Releases	2.2×10^{-5}	3.0	1.0	3.0
Process Incidents	$<1.0 \times 10^{-5}$	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	4.2×10^{1}	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation				
Routine Exposures	5.0×10^{-3}	6.3×10^{1}	1.0	6.3×10^{1}
Accidents	6.9×10^{-1}	1.2×10^{2}	1.3×10^{-4}	1.6×10^{-2}
Storage				
Expected Releases	Negligible	1.3×10^{2}	1.0	1.3×10^{2}

Time-Integrated Risk, 300 years man-rem[b]	6.5×10^{2}
Time-Integrated Risk, 10,000 years, man-rem	6.5×10^{2}

a. Equivalent whole body dose, rem.

b. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-14

Summary of Exposure Risks for Alternative 2, Subcase 2 — Glass Stored in Onsite Surface Storage Facility

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing				
Routine Releases	2.2×10^{-5}	3.0	1.0	3.0
Process Incidents	$<1.0 \times 10^{-5}$	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	4.2×10^{1}	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Sabotage	1.9	3.8×10^{3}	1.0×10^{-5}	3.8×10^{-2}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Abandonment	Negligible	0	-	0
Time-Integrated Risk, 300 years man-rem[a]	2.2×10^{2}			
Time-Integrated Risk, 10,000 years, man-rem	3.4×10^{2}			

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-15

Summary of Exposure Risks for Alternative 2, Subcase 3 — Glass Stored in SRP Bedrock

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, /year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{-2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing				
Routine Releases	2.2×10^{5}	3.0	1.0	3.0
Process Incidents	$<1.0 \times 10^{-5}$	4.2×10^{-1}	1.0	4.2×10^{-1}
Sabotage	4.2×10^{1}	8.9×10^{4}	1.0×10^{-5}	8.9×10^{-1}
Airplane Crash	1.5×10^{-1}	3.1×10^{2}	7.0×10^{-8}	2.2×10^{-5}
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Expected Releases	Negligible	1.3×10^{2}	1.0	1.3×10^{2}
Time-Integrated Risk, 300 years man-rem[a]	3.4×10^{2}			
Time-Integrated Risk, 10,000 years, man-rem	3.4×10^{2}			

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-16

Summary of Exposure Risks for Alternative 3 — Unprocessed Waste Slurry Stored in SRP Bedrock

Event	*Maximum Individual Dose, rem*	*Population Dose for Maximum Year, man-rem*	*Probability, Events/year*	*Maximum Risk, man-rem/year*
Removal from Tanks				
Routine Releases	Negligible	1.4	1.0	1.4
Sludge Spill	5.0×10^{-4}	1.5×10^{1}	5.0×10^{-2}	7.5×10^{-1}
Spill at Inlet	1.2×10^{-3}	3.7×10^{1}	5.0×10^{-2}	1.9
Tornado	2.0×10^{-3}	5.4×10^{1}	6.0×10^{-4}	3.2×10^{-2}
Spill	2.9×10^{-2}	1.1×10^{3}	5.0×10^{-3}	5.4
Explosion	7.8	3.0×10^{4}	1.0×10^{-4}	3.0
Sabotage	1.2×10^{2}	3.5×10^{5}	1.0×10^{-5}	3.5
Below-Ground Leaks	1.5×10^{-1}	1.7×10^{5}	1.0×10^{-5}	1.7
Processing	Not applicable	Not applicable	Not applicable	Not applicable
Transportation	Not applicable	Not applicable	Not applicable	Not applicable
Storage				
Expected Releases	Negligible	1.3×10^{2}	1.0	1.3×10^{2}
Earthquake with Shaft Open	7.6×10^{3}	3.8×10^{8}	3.3×10^{-5}	1.3×10^{4}
Earthquake after Sealing	$<1.7 \times 10^{2}$	8.3×10^{6}	3.3×10^{-6}	2.8×10^{1}
Sabotage before Sealing	3.0×10^{4}	1.5×10^{9}	1.0×10^{-5}	1.5×10^{4}
Sabotage after Sealing	2.8×10^{2}	1.4×10^{7}	3.3×10^{-10}	4.6×10^{-3}

Time-Integrated Risk, 300 years, man-rem[a]	6.2×10^{4}
Time-Integrated Risk, 10,000 years, man-rem	1.4×10^{5}

a. Integrated annual population risk, accounting for radioactive decay and population growth by a factor of 5.

TABLE V-17

Moderate and Nondesign Basis Accidents Postulated for Repository in Salt

Accident Description	*Sequence of Events*	*Safety System*	*Release, Ci*	*Probability*
Canister drop in surface facility	Canister handling crane fails Canister breaches on impact	Positive latching grapple system and conservatively sized crane Building filter system	$3x10^{-4}$, ^{90}Sr; $3x10^{-4}$, ^{137}Cs; $1.5x10^{-6}$, ^{238}Pu; $6.0x10^{-8}$, ^{239}Pu; to building atmosphere	2×10^{-7}/yr
Canister drop down mine shaft	Canistered waste shaft hoist fails Canister breaches on impact	Failsafe wedge type braking system Mine exhaust filter system	$1.5x10^{4}$, ^{90}Sr; $1.5x10^{4}$, ^{137}Cs; $7.5x10^{1}$, ^{238}Pu; 2.9, ^{239}Pu; of small particles to mine atmosphere	1.3×10^{-8}/yr
Nuclear warfare	50-megaton nuclear weapon bursts on surface above repository Crater formed to 340 m with fracture zone to 500 m	Repository depth of 600 m	None	
Repository breach by meteor	Meteor with sufficient mass and velocity to form 2-km-dia crater impacts repository area 2-km-dia crater extends to waste horizon, dispersing 1% of waste to atmosphere	Repository depth of 600 m	$1.3x10^{6}$, ^{90}Sr; $1.3x10^{6}$, ^{137}Cs; $6x10^{3}$, ^{238}Pu; $2.4x10^{2}$, ^{239}Pu; half to stratosphere, half as local fallout	2×10^{-13}/yr
Repository breach by drilling	Societal changes lead to loss of repository records and location markers Drilling occurs 1000 yr after closure	Repository depth of 600 m Repository marked by monuments and records kept securely Site criteria - not desirable resources	$7x10^{-7}$, ^{90}Sr; $7x10^{-7}$, ^{137}Cs; $7x10^{-3}$, ^{238}Pu; 1.5, ^{239}Pu; distributed in drilling mud over 1.2 acres in the top 2 in. of soil	Not determined
Volcanism	Volcanic activity at repository carries wastes to surface	Site criteria - no history or potential for volcanic activity	Less than accident below	Not determined
Repository breach by faulting and groundwater transport	Fault intersects repository Access is created by pressure between aquifer, waste, and surface Aquifer carries waste to surface	Site criteria - low seismic risk zone Site criteria - minimal groundwater Repository depth of 600 m	$6x10^{-4}$, ^{90}Sr; $6x10^{-4}$, ^{137}Cs; 6, ^{238}Pu; $1.2x10^{3}$, ^{239}Pu; released to the groundwater 1000 yr after mine closure	2×10^{-13}/yr
Erosion	Repository overburden subject to high erosion	Site criteria - low erosion rates Repository depth of 600 m	Less than breach by a meteor	Not determined
Criticality	Criticality not feasible	—	—	—

TABLE V-17A

Possible Exposures and Risks from Geologic Repository

Accident Description	*Maximum Individual Exposure, rem (70-yr whole-body commitment)*	*Maximum Individual Risk, Probability Times Consequence, rem/year*
Canister drop down mine shaft	1.4×10^{-5}	1.8×10^{-13}
Repository breach by meteor	5.5×10^{6}	1.1×10^{-6}
Repository breach by faulting and flooding	7.4×10^{3}	3.0×10^{-11}
Repository breach by drilling	1.1×10^{4}	Probability Intermediate ($<5 \times 10^{-3}$)

4. Offsite Land Contamination

Levels of radionuclide deposition that would require evacuation of people and restrictions on farming and milk production are discussed in more detail in Reference 8 and are given below in Table V-18. The deposition limits were derived from the dose criteria given in Table V-19, which are also discussed in Reference 8.

TABLE V-18

Radionuclide Deposition Limits for Evacuation and Restrictions on Farming, Ci/m^2

	Evacuation		*Restrictions on Farming*	
Isotope	*Direct Radiation*	*Inhalation*	*First Year*	*Long Term*
^{90}Sr	-	2×10^{-4}	4×10^{-5}	2×10^{-4}
^{137}Cs	3×10^{-5}	1×10^{-3}	2×10^{-6}	8×10^{-5}
$^{238,239}Pu$	-	1×10^{-7}	-	-

TABLE V-19

Radiation Dose Criteria

Evacuation Limits	
External Irradiation	10 rem to whole body in 30 years
Inhalation	75 rem to critical organ in 50 years
Farming Restrictions (Short Term)	
^{90}Sr	5 rem to bone marrow in first year[a]
^{137}Cs	5 rem to whole body in first year[a]
Farming Restrictions (<1 year)	
^{90}Sr	(5 rem to bone marrow in 50 years)/year
^{137}Cs	(1 rem to whole body in 50 years)/year

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a. The 50-year dose commitments due to these exposures in the first year are about 25 rem to the bone marrow from ^{90}Sr and 5 rem to the whole body from ^{137}Cs. (Almost all the dose from ^{137}Cs is received in the year in which it is ingested.)

Only two operational modules have potential for causing off-site land contamination for any of the abnormal events considered. These two are sabotage during removal of waste from tanks (common to all three alternative plans), and sabotage during processing waste to glass (unique to Alternative 2). The consequences, if each of these events did occur, are given in Tables V-20 and V-21, respectively, in terms of land contaminated and people evacuated.

TABLE V-20

Contamination Effects from Sabotage During Removal of Waste from Tanks

Distance from Release, km	*Acres Requiring Decontamination*	*People Moved*
15-20	8.5×10^3	2.2×10^3
20-25	1.1×10^4	3.2×10^2
25-30	1.3×10^4	0
30-35	1.6×10^4	0
35-40	1.8×10^4	0
40-45	2.1×10^4	0
45-50	2.3×10^4	0
50-55	2.5×10^4	0
55-60	0	0
Total Offsite	1.3×10^5	2.5×10^3

TABLE V-21

Contamination Effects from Sabotage During Waste Processing

Distance from Release, km	*Acres Requiring Decontamination*	*People Moved*
15-20	8.5×10^3	0
20-25	0	0
Total Offsite	8.5×10^3	0

5. Nonradioactive Pollutants

There will be no unusually large stores of chemicals required for implementing any of the alternative plans. Therefore, there is little potential for pollutant release to the environment for the abnormal events considered. Furthermore, mitigating features such as sand filters and liquid diversion systems would be expected to retain most accidental releases. Operations have been conducted over the past 27 years at SRP using large quantities of such chemicals as nitric acid and hydrogen sulfide with no adverse effect on the environment, as discussed in Reference 11. Similar experience for releases attributable to abnormal events is expected to apply to any future waste management operations.

If a high-activity fraction is separated from the waste and subsequently processed to a high integrity form such as Alternative Plan 2, there will remain about 16 million gallons of decontaminated salt cake. This salt could be stored in decontaminated waste tanks existing after processing, and would be subject to occurrence of the abnormal events discussed previously. The worst of these would be abandonment, with subsequent filling of the tanks with rain-water and runoff to the Savannah River. This scenario was analyzed in Reference 8, and the consequences are given in Section IV.C.3. of Reference 8. Not only is this event considered very unlikely, but also the river would not be polluted above drinking water standards even if no corrective actions were taken.

D. POTENTIAL EFFECTS FROM DECOMMISSIONING OPERATIONS FOR EACH ALTERNATIVE

1. Description of Decommissioning Technology

This section refers to the status of waste management facilities after decommissioning and the environmental impacts of decommissioning actions. Some decommissioning options would leave a residue of low-level radioactive waste, and this waste would be managed like the large volumes of low-level waste already in existence. Documents covering alternatives for long-term management of defense low-level waste are now in preparation by DOE.

SRP Waste Tanks

A program is now underway at SRP to retire waste tanks of the first three designs used at the plant. These tanks are being replaced with tanks incorporating design features (such as stress relief after construction) that are expected to increase useful lifetime and reduce maintenance costs. The technology developed for removing the waste from the retired tanks is applicable to decommissioning* all the tanks. A program of tank decommissioning would be implemented no matter which alternative plan is selected, because even continued tank farm operation will require tank replacement at intervals of about every 50 years. Decommissioning involves four major operations:

1. Removal of cake precipitated from solution during aqueous waste volume reduction is accomplished by dissolution with water heated to 90°C. The dissolution is enhanced by the use of movable agitation steam jets. The solvent water for these operations is recycled from evaporator overheads and other waste water, thereby minimizing the use of fresh water and discharges to the environment. To prevent airborne contamination from escaping through tank top apertures, a negative pressure in the tank is maintained.

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* Decommissioning is defined in ANSI Standard N300-1975 as the planned and orderly execution of a program devised for a nuclear facility to achieve a substantial and permanent improvement in the status of the shutdown facility. The program includes 1) decontamination of the structures, 2) removal of sources of radioactivity, 3) return of the site to a condition wherein it may safely be returned to unrestricted use, and 4) surveillance required for the protection of the public health and safety for a specified time if it is shown to be technically or economically infeasible to decontaminate the site to levels acceptable for unrestricted use.

2. Some of the tanks contain a sludge of waste particles that are insoluble in water. Removal of the sludge is accomplished by suspending it in a supernate solution from another tank and pumping to a settling tank or hold tank. Supernate is used as the sludge slurrying medium to avoid adding large volumes of new water into the waste tank system. This technique minimizes the amount of later evaporation required, and the number of hold tanks needed. The slurrying pumps are movable, and operation with a 1:1 ratio of supernate to sludge at a moderate pressure of about 100 psig gives an effective clearing radius of greater than 20 ft around each pump position.

3. After hydraulic sludge suspension of slurry removal, a sludge residue remains on the interior surface of a tank. Typically 4 wt % oxalic acid solution heated to 85°C is used through spray nozzles to dissolve this residue. The resulting solution is pumped to a hold tank, neutralized, and evaporated. The tank interior is finally washed with fresh water.

4. Salt deposits may have formed around any leak sites into the annulus between the primary container and the outer wall of the double-wall tanks. If so, hot water circulated by steam jets is used to dissolve these deposits in conjunction with the final sludge slurry transfer and with the water wash step of chemical cleaning in the tank interior. The annulus is then washed with fresh water.

Transfer of salt, supernate, and small amounts of sludge from retired tanks to new tanks has been demonstrated. Tests are now under way at SRP to transfer sludge and chemically clean retired Tank 16H. This will be a test of the process and equipment, rather than of the ultimate cleanliness attainable. Specific goals for the level of decontamination required for decommissioning of the SRP waste tanks are now being formulated through NRC-DOE-SRP discussions.

Processing Building

The technology and safety of decommissioning large processing facilities for radioactive materials have been studied recently and are detailed in Reference 18. The technology for decommissioning radioactive cells of the processing building is the same as that used presently for decontaminating hot cells. Caustic and/or acid washes are combined with the use of strippable paint to remove most contamination. Sandblasting or chipping of concrete can be used for especially resistant localized areas. Large pieces of equipment can be removed and cleaned by the above techniques and by electrolytic polishing. Present conceptual design for a processing building that would be used at SRP includes stainless steel liners on the cell floors and lower walls. The ability to remove these liners is expected to significantly decrease required decontamination efforts.

2. Decommissioning Options

Decommissioning alternatives range from leaving the tanks and processing building in place, with minimum removal of residual radioactivity and continuing surveillance and control, to dismantling and releasing the areas for unrestricted use. Each decommissioning mode requires a different degree of cleanliness. Although the alternatives can be identified, the criteria for cleanliness can only be provided on a tentative basis because of the lack of comprehensive regulatory guidance. Specific criteria for decommissioning within the framework of DOE and NRC guidelines is being developed as part of a research and development program that began in FY-1979.

The NRC guidelines on reactor decommissioning, particularly Regulatory Guide 1.86, and the extensive PNL document[19] on the decommissioning of a reprocessing plant give sufficient information to identify with considerable certainty the current decommissioning alternatives for SRP waste facilities. The objective of all of the alternatives is to ensure the continuing protection of the public. The resulting risk to the public must be acceptable, whichever of the following options is selected:

- Protective Storage (Mothballing). Most of the radioactivity would be removed from the facilities, but substantial quantities could remain. Openings in the facilities would be sealed, and other actions would be taken to place the tanks and buildings in a condition that requires a low-level effort of continuing surveillance, maintenance and security. Compared to other alternatives, this option requires a minimum of near-term effort and the lowest initial expenditure. The protective storage mode could be employed as a temporary action, a prelude for later extensive decommissioning.

- Entombment. In-place entombment consists of sealing all the residual radioactivity within a high-integrity durable structure. The structure should provide containment over the period of time that the residual radioactivity remains hazardous. This decommissioning effort would be much more extensive than for the protective storage mode. "Hardened" sealing would be used to isolate the remaining radioactivity from man. For example, the tanks and processing cells may be required to be filled with concrete or another suitable material.[19] Entombment may be found to be most suitable for a facility containing relatively short-lived radionuclides that decay to innocuous levels within a few centuries. At the end of that period, all restrictions on the use of the facility could be eliminated. A surveillance effort would continue during entombment, but to a lesser extent than for the protective storage mode.

- Unrestricted Release. For this alternative, all potentially hazardous amounts of radioactive materials would be removed from the tank farm areas and processing building. This could be done by extensive decontamination of the facilities that would result in a very low level of residual contamination or by dismantling and removing from the site all material that exceeds an acceptable contamination level. In either case, the remaining radioactivity would be innocuous and the site, either with or without the tanks and buildings, could be released for unrestricted use.

The unrestricted release mode may be deferred by first proceeding through the protective storage or entombment modes. However, unrestricted release after entombment would be far more difficult and costly than release after the protective storage mode. The entombment option was rejected for this reason in the PNL study.

Beyond the identification of decommissioning alternatives, regulatory guidelines are limited on other aspects of decommissioning, such as acceptable contamination levels. In recognition of the need for additional NRC regulations, the Advisory Committee on Reactor Safety has recently begun hearings with the aim of preparing recommendations to the Commission on the development of new rules for deactivation of nuclear facilities. Furthermore, NRC is funding a PNL study on the technology, safety, and costs of decommissioning a reprocessing plant. This study, which is based on the hypothetical retirement of the Barnwell Nuclear Fuel Plant, could establish a technical basis for specific decommissioning regulations and guidelines for reprocessing plants, including waste tanks. In addition, DOE is planning a comprehensive program to develop technology needed for decommissioning. The results of the NRC and DOE efforts will serve as the basis for the future decommissioning program for SRP waste management programs.

3. Occupational Radiation Exposure and Non-Nuclear Occupational Effects

All the basic operations involved in the decommissioning options have been carried out in the past. These include transfer of waste from tank to tank, decontamination of hot cells at SRP, and dismantlement or decontamination of other DOE facilities. There is nothing inherent about these decommissioning operations that would preclude their meeting the standards of occupational radiation exposure and safety discussed previously in Sections V.A., V.B., and V.C.

4. Offsite Effects

Offsite releases of radioactivity from decommissioning activities would be required to meet the same government regulatory standards discussed in Section V.A. (DOE Manual Chapter 0524) for releases from the waste management operations. However, the releases from decommissioning would have an inherent likelihood of being much lower because the total curies of activity processed would be many thousands of times lower. The operations involved in most decontamination steps, such as handling and evaporation of wash water and chemical cleaning solutions, are the same as those used in the primary waste management phase and introduce no new potential for radioactive release. It is concluded, therefore, that there will be no significant offsite radiation effects from any of the decommissioning options that might be implemented.

5. Impacts to Future Generations from Decommissioned Facilities and Land

All of the decommissioning options discussed in Section V.D.2. leave the facilities in such a condition that no radiation exposures could be incurred by any sizable portion of even the nearby population. The difference lies in the fact that a few individuals would be more protected from harm from their own actions than for others. For example, if waste tanks and reprocessing cells were dismantled and disposed of in a geologic repository along with the high-level waste, there would be no potential for anyone receiving radiation exposure at the site. In contrast, if those facilities were cleaned to a moderate degree and mothballed, and if surveillance and control were later lost, then some individuals could enter the tanks or cells (which would require considerable deliberate action) and receive undesirable radiation exposures.

Other differences in the way decommissioning options impact future generations are in the requirement for surveillance and control and in dedication of land. None of these differences is large, because in no case are more than a minimal surveillance effort and a few acres of land involved. The question of whether the reduced risk to some hypothetical future individuals committing unwise acts (such as deliberate intrusion or inadvertent use of contaminated land) and the availability of a few acres of land for unrestricted use are worth the extra monetary cost is a sociopolitical question that will best be answered at some time in the future by regulatory agencies. However, pertinent to the present decision-making process, there are no features of the research and development activities or of the three major waste management alternative plans that foreclose the availability of several reasonable decommissioning options for the future.

E. POTENTIAL EFFECTS FROM DECONTAMINATED SALT STORAGE

1. Storage in Waste Tanks at SRP

Various potential release mechanisms were evaluated for terminal storage of salt cake in tanks, and it was found that intense earthquakes pose the greatest risk. If an intense earthquake occurred immediately after the salt is stored, the tanks could be damaged and fill with rainwater. If they were then abandoned, they could overflow to the Savannah River during an extended period. If no corrective actions were taken and if people continued to drink the downstream river water and eat downstream fish, the consequences given in Table V-22 could be realized. Table V-22 also gives the annual risk from this event by multiplying the consequences by the probability of occurrence of the earthquake. The risk and cost of this storage mode are compared with those of the other storage alternatives in Table V-23.

2. Can and Store in an Onsite Surface Vault

Canisters containing the decontaminated salt are stored in a surface storage vault similar to the vault described in DPE-3410.[20] An evaluation of the various potential release mechanisms from the storage vault indicates that intense earthquakes present the greatest risk. The vault will be designed and constructed to withstand completely earthquakes of the intensity which might reasonably be expected to occur in the vicinity of SRP (see discussion of seismicity in Section III.) An earthquake of intensity MM IX would be expected to cause some cracking of the surface storage vault. An earthquake of greater intensity could cause extensive cracking of the concrete structure and could rupture some of the canisters stored in the vault. The probability of an earthquake of an intensity of MM X occurring at SRP is 2×10^{-5}/yr.

The canisters of salt are stored individually in storage wells located in the reinforced concrete slab floor of the vault. Each storage well will have a concrete closure plug. The closure plugs are assumed to remain in place with little lateral displacement after an earthquake. Therefore, rainwater dissolution of salt from damaged canisters with runoff to the river would occur much slower from this type facility than from waste storage tanks because the salt is not as accessible to rainwater.

If no corrective actions were taken following an earthquake of MM X and if people continued to drink the downstream river water and eat downstream fish, the consequences would be less than the exposures shown in Table V-22. When the exposures in Table V-22 are multiplied by the decreased probability of an earthquake of MM X (2×10^{-5}/yr versus 10^{-3}/yr for an MM IX earthquake), the risks become insignificant.

TABLE V-22

Dose to Individual Drinking River Water and/or Eating Fish after Runoff from Decontaminated Salt Tanks Damaged by an Earthquake[a]

Nitrate-Nitrite Concentrations	0.027% EPA drinking water limit
Mercury Concentrations	0.13% EPA drinking water limit
Individual Whole Body Dose, Drinking Water	0.17 mrem/yr
Individual Bone Dose, Drinking Water	0.08 mrem/yr
Individual Whole Body Dose, Eating Fish[b]	11 mrem/yr
Population Dose Risk over 105-Year Period[c]	7.2 man-rem

a. Assumes the amount of residual radioactivity in the tanks after decontamination is equal to or less than the radionuclide content of the salt and that 10% or less of the residual activity is transferred to the salt. Also assumes 25% of the tanks containing salt are damaged and 10% of the salt and radionuclides released from the tanks reach the river.

b. Assumes this individual eats 25 pounds of fish per year. The present commercial fishing industry could supply about 200 such people.

c. Based on a probability of 10^{-3}/yr for an earthquake of intensity of MM IX which is required to damage the tanks containing salt. Assumes 25% of the tanks are damaged. Estimates show that 100 years are required for rainwater entering the tanks to dissolve the salt and empty the tanks. Also assumes the population drinking water and eating fish caught commercially increases by a factor of 5 during the period.

TABLE V-23

Salt Storage Risk and Cost

	Tank Storage	*Onsite Surface Vault*	*Offsite Geological Storage*
Risk, man-rem[a]	7.2	0.14	1405[b]
Cost, millions 1978 dollars	57	1127	481

a. Exposure to offsite population, excludes occupational exposure.

b. Exposure for shipment by rail, including train crew. Exposure for shipment by truck would be 6770 man-rem which includes exposure to drivers.

3. Can and Store in an Offsite Federal Repository

The environmental effects of storage in an offsite Federal repository will be assessed in an environmental impact statement for the repository. However, since it has been shown that the environmental effects of the high activity fraction are negligible, the radiation effects of the decontaminated salt would also be negligible.

An evaluation of the radiological impact of transporting the salt indicates that exposure to radiation during transport presents the greatest risk. For the purpose of calculating the exposure, it was pessimistically assumed the radiation level 6 feet from the surface of the truck or train car is 10 mrem/hr, the upper limit permitted by Federal Regulations 10 CFR 71 and 49 CFR 170-9. Other assumptions are:

- A truck carries two drivers and averages 40 mph.
- A train car averages 10 mph.
- The population density beginning 100 ft on either side of the road or railway is 250 people per square mile.

For truck transport, estimated doses were based on assumptions that:

- Two drivers occupy the cab.
- The dose rate in the cab is 2 mrem/hr (as limited by 10 CFR 71).

- Two garagemen work on the truck each 1000 miles for 10 minutes in a 2 mrem/hr radiation field.

- 165 vehicles pass the truck each hour at a relative speed of 10 mph; each vehicle contains two people, and they are exposed at a distance of 6 ft from the side of the truck.

- Ten onlookers spend three minutes each, 3 ft from the side of vehicle, each 1000 miles of truck travel.

For train transport, extimated doses are based on assumptions that:

- Three crewmen spend half their time 300 ft from the cask.

- Ten brakemen spend 5 minutes each 6 ft from the side of the car carrying the cask each 1000 miles of travel.

- One passenger train carrying 300 passengers per day passes the cask at a relative speed of 30 mph; the passengers are at an average distance of 10 ft from the cask.

- Ten onlookers spend 3 minutes each 3 ft from the side of the train car each 1000 miles of car travel.

The radiation dose to transport workers and the public, under normal shipping conditions, calculated for shipping the salt a distance of 2000 miles, is shown in *Table V-24*. Shipment by rail would result in about 140 man-rem/year, while shipment by truck would result in about 675 man-rem/year (over the 10-year shipping period). Most of the difference is due to the doses to the truck drivers.

TABLE V-24

Radiation Doses for Salt Shipments Under Normal Conditions (For shipment 2000 miles from SRP)

	Total No. of Shipments in 10-Year Shipping Period	*Total Dose for All Shipments, man-rem*		
		To Transport Workers	*To Public*	*Total*
Truck	23,625	4,265	2,505	6,770
Rail	23,625	445	960	1,405

The greatest risk associated with shipping the decontaminated salt to an offsite Federal repository is from the physical injuries and deaths from transportation accidents. For transportation by truck, the probability[21] per vehicle mile for injuries is 9×10^{-7} and for fatalities is 5×10^{-8}. The probability[21] per car mile by rail for injuries is 4×10^{-7} and for fatalities is 3×10^{-8}. Assuming 23,625 canisters of salt are shipped 2000 miles to a Federal repository with one canister per rail car or truck, there would be approximately 38 injuries and 3 fatalities for rail shipments, and 85 injuries and 5 fatalities for truck shipments.

The canisters would be shipped in a cask that would provide thermal and shock protection for the canister of salt in the event of an accident. During transport, the probability/vehicle mile for releasing a small quantity of salt in an accident environment is about 1×10^{-10} for truck or 2×10^{-10} for rail car.[17] Assuming an accident occurs in which a damaged salt canister enters a stream with 100 cfs flow rate and all the salt is dissolved and released from the canister in 24 hours, an individual drinking water from the stream would receive a whole body dose of 0.08 mrem/yr and a bone dose of 0.04 mrem/yr. The consequences are nil even before multiplying by the extremely low probability.

F. SECONDARY (INDIRECT) ENVIRONMENTAL EFFECTS OF ALTERNATIVES

There have been no secondary environmental effects identified for any of the waste management alternatives that are not inside the usual range of environmental effects from operation of the Savannah River Plant. The possible exception is the increase in the construction force from 1000-3000 to about 5000. The following is a brief discussion of some of the items that have the potential for important secondary effects. In this context, secondary effects refer to changes in environmental, social and economic activities likely to be induced by implementation of an alternative waste management plan.

- The materials used in large quantity in any of the alternative plans are water, concrete, steel, glass formers, stainless steel, caustic, nitric acid, and oxalic acid. These are all common industrial products, and the SRP demand would be spread over several years with lead times such that external supplies and markets would not be affected. During certain phases of construction of any processing facilities and during the containerization steps if the glass waste form is chosen for surface storage, a relatively high number of stainless steel welders will be used. However, there will be enough lead time to train these personnel so that their skills are not considered to be a limiting item in implementation, and the use of skilled manpower will be mitigated somewhat by use of machine welding for containerization.

- If one of the geologic disposal alternatives is implemented, the materials disposed of will be irretrievable by future societies. Present day perceptions of utility are that such materials would be of no use in the future. If future perceptions of utility are different, then geologic disposal would have foreclosed an option for the future.

- Making a choice now for irretrievable disposal rather than for retrievable storage deprives future societies of the use of the technology and judgment that would accumulate over the storage period and it maximizes future regrets if it is later found that geologic disposal is not the most desired alternative. The extent that this might cause extra efforts by future societies is a secondary environmental effect of the present decision.

- It is concluded that the most important secondary effects are reflected in the large cost differences among the alternative plants. The difference of several billion dollars between the most expensive and least expensive alternatives represents, on the average, money diverted from the broad range of productive activities, goods, and services (including environmental improvements) included in the Gross National Product. As a limiting case for environmental effects, it might be considered that the full cost difference could be available to spend completely on other environmental improvement areas, and that implementation of the more expensive alternatives forecloses those improvements.

- Successful demonstration of long-term management of defense waste could have an important sociopolitical bearing on the acceptability of nuclear power generation by a significant portion of the public. If this increase in public acceptability resulted in greater utilization of nuclear power, there would be a net gain in the national economy and in resource conservation that would exceed the cost of the most expensive alternative for long-term management of SRP defense waste.

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